- SYSBAT - AN APPLICATION TO THE BUILDING PRODUCTION BASED ON COMPUTER SUPPORTED COOPERATIVE WORK

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ABSTRACT : *Our proposed solution is to enable partners of a construction project to share all the technical data produced and handled during the building production process by building a system through the use of internet technology. The system links distributed databases and allows building partners to access remotely and manipulate specific information. It provides an updated building representation that is being enriched and refined all along the building production process. A recent collaboration with Nemetschek France (subsidiary company of Nemetschek AG, AEC CAD software leader) focus on a building product repository available in a web context. The aim is to help building project actors to choose a technical solution that fits its professional needs, and maintain our information system with up to date information. It starts with the possibility to build on line building product catalogs, in order to link Allplan CAD entities with building technical features. This paper presents the conceptual approaches on which our information system is built. Starting from a general organization diagram organization, we focus on the product and the description branches of construction works (including last IFC model specifications). Our aim is to add decisional support to the construction works selection process. To do so, we consider the actor's role upon the system and the pieces of information each one needs to achieve a given task.*

KEYWORDS : *AEC, Data Base Management Systems, Production Management, Concurent Engineering, Product / Process Models, Information Systems, Information Tracking, Remote Work.*

1. INTRODUCTION

The building activities faces problems in management of information all along the designing, engineering, realization and maintenance stages. Architectural projects tend to be more complex and integrate a growing number of regulation requirements and constraints :

? user conveniences (accessibility, acoustic and thermic conveniences, etc.),
? construction (paraseismic properties, complex cost management, etc.),
? implementation (product selection, technical regulations, quality management, reduced construction duration),
? management of data generated by a growing number of partners with specific skills and points of view.

With the introduction of Information Technology, the exchange of information improves between the different partners which helps to improve the productivity of building activities. The goal of our research program is to share and extract data from the building description and to keep track of all the information changes and updates along the lifecycle of the building. To reach these objectives, it is necessary to build an agile information system framework that would support the management of data. In addition, it means that there must be a normative approach, to the description of the building elements, in order to ease the access and re-use of technical solutions. Many research programs in the building construction industry conducted world wide are focused on these normalization topics based on other industrial areas. (Automotive, Aviation, Electronics, etc.) [Celnik, Coste and Vincent, 1993], [Chan and Gu, 1993] and [Chen and Wu]. The solution covers re-engineering and knowledge management, which are used in other industrial areas [Darses, 1997].

2. DATA EXCHANGE IN BUILDING CONTEXT

Building production is a non-linear complex activity. It is sequenced by distinct stages in which many actors contribute to the project description with their own vocabulary and competence. All the actors involved are working towards the same goal : the completion of the construction project (figure 1. & 2.). Building related documentation (Graphical and Textual) produced are shared amongst all parties of the building project. These kind of documentation ensure an efficient and accurate flow of information.
The data manipulated by partners who collaborate in raising the building is often compiled into professional systems and cannot be re-used by the other users. The data is transformed through these systems and the added value can not be understood [Belhi, Erad and Bouras, 1999].

Figure 1. & 2. The Photograph and the completion technical plans of the European Parliament in Strasbourg designed in 1993 by Architecture-Studio (France). © http://www.architecture-studio.com/

The problem of data exchange between heterogeneous CAD systems produced diverse file exchange formats : DXF, IGES, SET, VDA, CALS, STEP and more recently Industry Foundation Classes (IFC) from the IAI (International Alliance for Interoperability) that are unable to inter-operate efficiently with one another. IAI is the most advance, because it involves main CAD system firms,.a large population of CAD users and institutional partners. French research projects (SUC, MOB, GSD, SIGMA, etc.) and international projects (COMBINE, ATLAS, RATAS, IAI, etc draws a strong analogy between the architectural and the industrial field.
The goal of these research programs is to provide all parties in the building construction, tools for concurrent engineering and tighter co-operation amongst the partners in the building production processes. The various research works highlight two major trends in the way to describe a building :

? The focus on the technical data of the building construction works, and
? The focus on the process description that leads to the construction of the building.

The results of these works were used to develop the « Communication and CAD Tools » research program in our laboratory [Ameziane, 1998].

3. THE « COMMUNICATION AND CAD TOOLS » RESEARCH PROJECT

Our work originates from the results of previous projects we have dealt with, that are part of the « product/process model » research programs. It aims at providing an infrastructure that brings together, and promote co-operation between actors. This information system is initiated during the engineering stage, allow enhancement of the data through the execution stage, and will support the owner when the building is in maintenance.
We are answering to the problem of information continuity and fragmentation by sharing a unique data model amongst all parties involved into the building construction processes.
This project structure information into a conceptual schema of data matching the knowledge fields of architectural design. This schema allows to build a coherent group of entities in a Data Base Management System, from which a collaborative work can be set. During this activity, each partner can get the building representation (aggregate views of data) he needs to complete his report. (figure 3.)

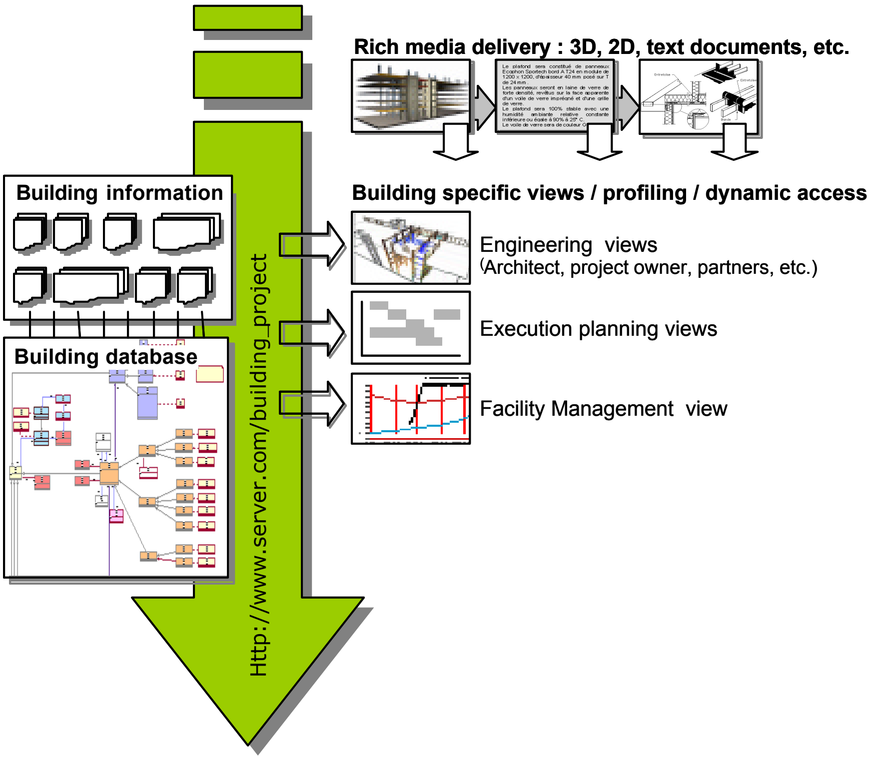

Figure 3. Overview of the « Communication and CAD Tools » project.

Our work was led by the following assumptions :

? the knowledge of the building construction area is distributed, but it can be accessed to through a network,
? a building can be described by a set of construction works and the spaces it contains. This is from the construction economist's stand point,
? level of information is growing step by step, and every partner can access it,
? we assume that a 3D CAD model was elaborated before the engineering stage. In our work area, it seems to be the best entry to support the finalization of the building project description.

To answer these assumptions, we produced a conceptual data diagram which describes the building through the construction works it is composed of. It consists of a generic class "BuildingEntity" and a set of branches that represents a specific domain of the building construction process.

Each branch then consists of a hierarchic set of sub-classes (fig. 4. & 5.). A building entity class has attributes (product specifications) and methods (specific product knowledge – for example, a HVAC dimensioning depends on the volume and the capacity of a room).

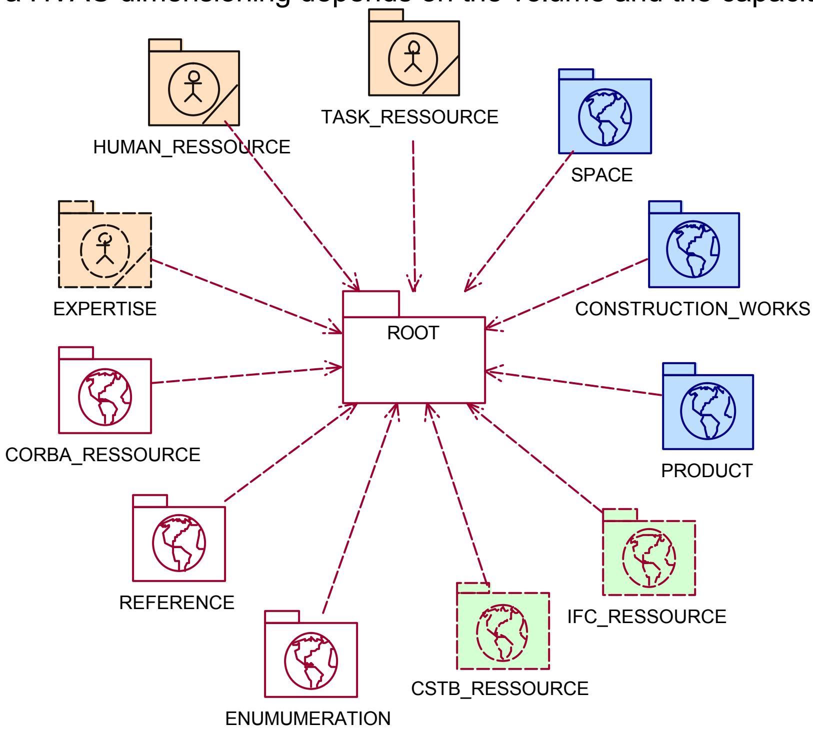

Fig. 4. The Information organization - Overview of main packages of classes.

In that prospect, we are implementing this conceptual schema into an Oracle 9i object-relational database. For every building construction project, a new database instance is created. Successive 3D representations of construction works can be stored, as well as the linked documents that complements their description.
The data can be accessed from a solid and parametric CAD system (Architectural Desktop by Autodesk Inc. and more recently Allplan by Nemetschek A.G.) or a web browser.
This system support collaborative work, ensure data continuity through all parties and keep track of design history. We remind that once the building has been built, its owner may legally request all the information compiled through the stages. During the operating stage of the building (the longest one), he needs to look after construction works maintenance and sometimes find the responsible of badly ones. In that case, he must be able to quickly find the defect inside the building design history. The less continuity breaks there are in the information history, the more efficient a search is.
In addition, since no real normative standard has been elaborated yet, this architecture ease the enhancement of the building description which needs to be frequently updated, through its data diagram

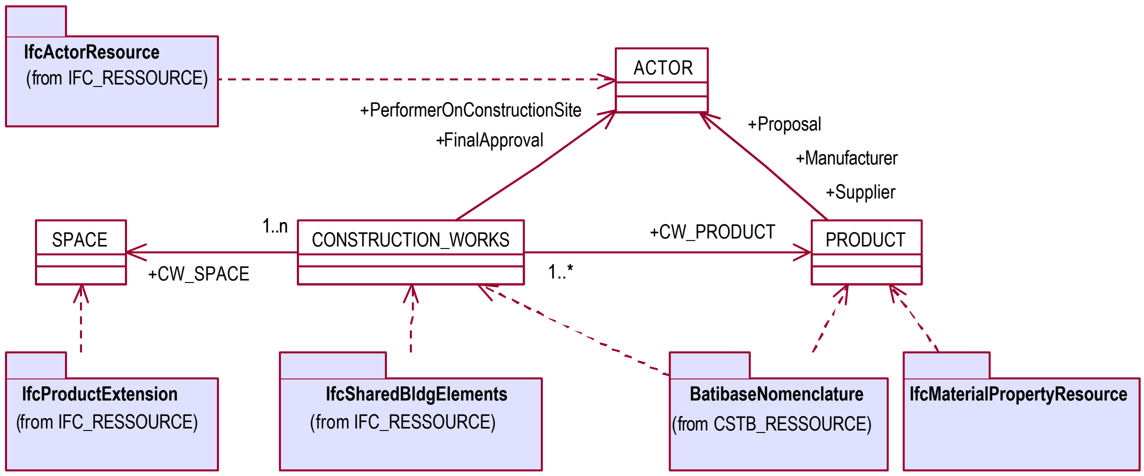

Fig. 5. An information structure extract including standards such IFC building object definition (Industry Foundation Classes from IAI). View of an Oracle database schema sample using the UML formalism.

4. PROFESSIONAL APPROACHES

Because not only is the data becoming richer and more complex, but also the frequency of exchanges is growing exponentially, each actor wants an aggregate view of the information to argue a suggestion out.
In France, with the statutory files related to construction specifications ("Cahier des Clauses Techniques Particulières", "Cahier des Clauses Administratives Particulières", "Dossier des Ouvrages Exécutés", etc.) a set of representations of the building is provided to each partner [Armand et Raffestin, 1993]. The contents of these documents depend on the actor's needs. We intend to build such e-folders by filtering the entire pieces of information.
By anticipating the product descriptions we can now access through the Internet, the aim is to demonstrate that a construction work's specification may be extracted from an exhaustive set of information which the contents depends on professional needs. This issue is very important to be able to answer to a multiple-expertise context. Building a "real time" representation of the building for each partner depends on the high availability of data.

5. PROFESSIONAL PROFILES

The lack of normative data classification and the speed of their progression during the production process give a dynamic aspect to the building information. Consequently, sequenced representations of these data are soon out of date [Ghodous and Vandorpe, 2000]. The architect being the actual database owner, he is responsible for coordinating the inputs from all the actors and updating the database, in order to provide the users with the latest and most accurate view of the building. The construction works description mechanisms are based on existing databases and the various professional profiles associated to it. Furthermore, beside these pieces of information are sometimes confidential for some teams, our professional approach is mainly focused on the possibility to make them more understandable. In that way, we are sure to improve the quality and the efficiency of the actor's report, with the help of refined search. We have worked on electronic representation of the files created during the design and engineering stages. It comes with personal information associated to a professional profile. Each actor is able to customize his default profile, from the rights given by a subordinate manager.

He can select the data he wants to screen on the next queries, as well as construction works graphic representations. Each space comes as a dynamic 3D file that depends on the selected graphical entities. This interactive 3D representation uses the Virtual Reality Modeling Language (VRML) computed on server side, according to the profile.

6. GOING TOWARD A DECISIONAL SUPPORT SYSTEM

In France, specific factors lead a decision regarding a construction work choice during the engineering stage. Given a role in the project, each actor (figure 6.) involved in the design process share knowledge fields with one another. They usually make a suggestion for a construction work according to their own knowledge and point of view on the building.

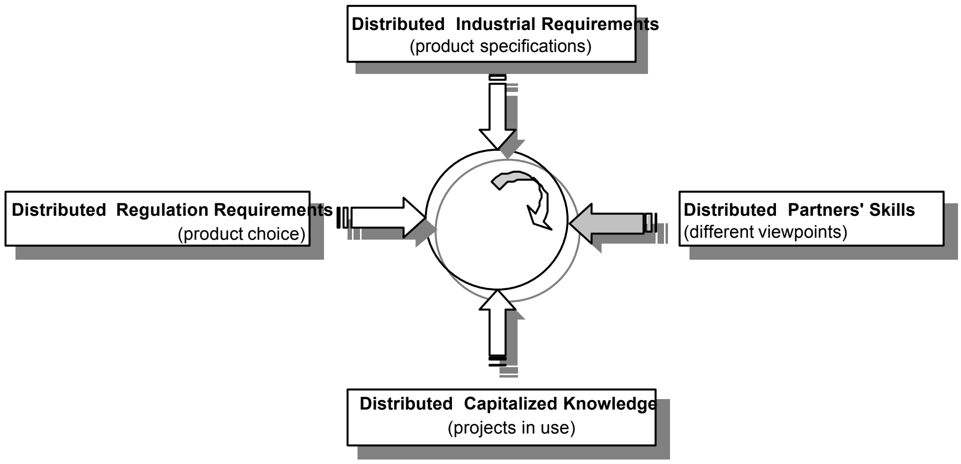

Figure. 6. Distributed knowledge for construction works decisions.

According to the construction industry process and organizational settings along, we assume that a decision support system should answer to these features :
- Take into account multi-actors needs and points of views,
- Answer to the iterative or incremental aspect of the decision process (range of solutions are refined step by step)
- Let choose between a technological approach[1] and a functional approach[2], and ease to pass from one design area to another.
- ease all essential sequences such analysis, reasoning, actor's compromising, and final approval

We experiment a data warehouse for building materials that can improve data extraction and support an actor's decision support process. We chose to structure data schema into a "snow flake" diagram, according to professional areas and topics (figure 7.). Querying the database for a suitable product, an actor is given a range of integrated solutions from specialised datamarts.

[1] Technological approach (forward chaining) : An expert is starting a new design process from the given constraints
[2] Functional approach (backward chaining) : An expert has already worked on a similar case and tend to bring the new constraints close to it. He can check whether they are suitable or he need to adapt the solution to them.

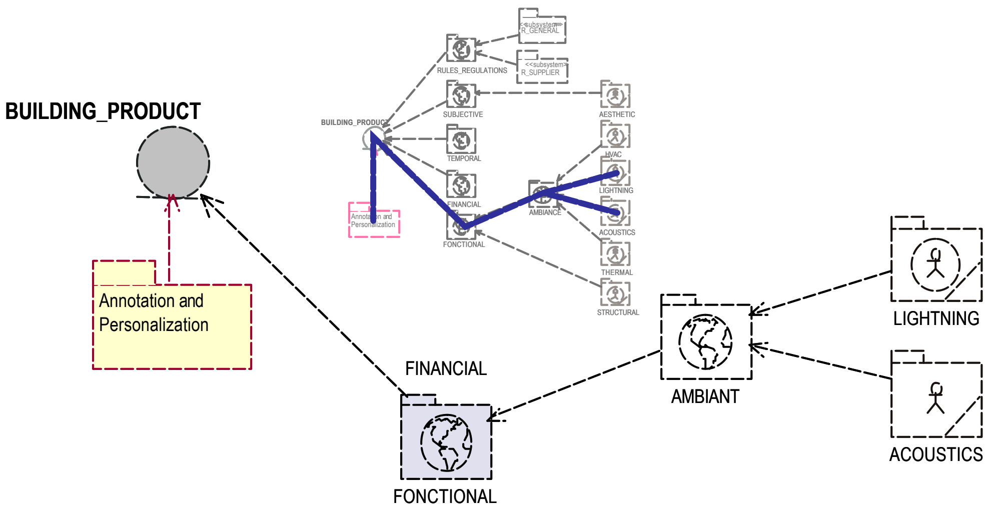

Figure 7. Extract of a data warehouse diagram for building material

Our first recent experiment has been made with the collaboration of Nemetschek France. Our purpose is to allow the users to get material descriptions from a web browser, to complement graphical entities description directly inside Allplan CAD System.
An actor can search a product by refining query and adding conditions step by step, until he gets a set of suitable ones. Then, he is able to add this material to a virtual catalog (like an e-commerce shopping cart function).
Finally the users can download the entire list structured by materials and may use it with Allplan CAD system. The next figure 8 shows the first experimental web site not yet opened for public use. We are still validating processes and improving product datawarehouse.

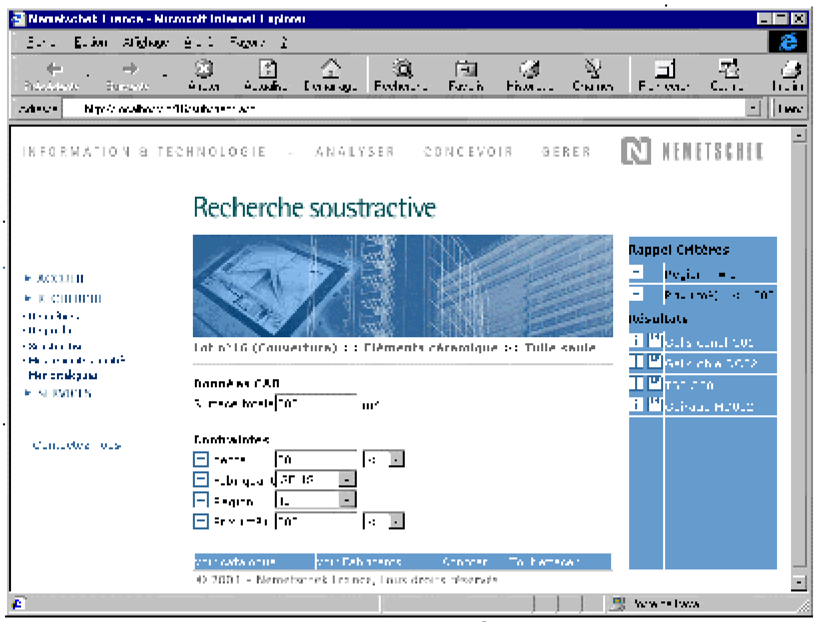

Fig. 8. First experiment with Nemetschek France for building product decisional support.

We are now focusing on the first results extracted from the analysis of a few user's behavior :

? the most used search criteria for a particular job profile,
? the search order (criteria apply).

The purpose is to build research sequences (specific wizards) based upon data mining concepts and web mining analysis, as an alternative iterative search to find a proper product. Given a "weight" each attribute would produce new decisional sequences and knowledge. Actually, we intend to give an answer to a complex non linear decisional support processes that involve specific actor roles and that can hardly be modeled in a computer system. In addition, the purpose is to catch the architect's conception intentions.

7. KNOWLEDGE MANAGEMENT APPROACH

As projects goes along, teams are capitalizing on professionalism, technical experiments and more largely know-how. We intend to enable the users to manage the information that describes and facilitates access to the knowledge they've got on their hands. This aim goes toward a functional approach by providing design references for reasoning and improving decisional process.
Our first approach is to ease the search for similar technical solutions from other building projects. Extracting data directly from project databases cannot be considered. First of all, queries wouldn't be optimised because our building data schema has not a suitable structure for that, and then, security reasons or confidential restrictions may apply to some parts of the building.
We rather suggest the built of a specific database that will represents one part of the corporate design memory. We assume that this database consists of a collection of construction works processed from other building projects data, at the end of the realization stage. A construction work is now structured into a data schema (figure 9.) as follows :

? Global functional description (the use, the materials specification, the domain, etc.) as elements of comparison,
? Process activity description (sequences of design changes and the argues, parties that were involved, etc.) to control design chain.

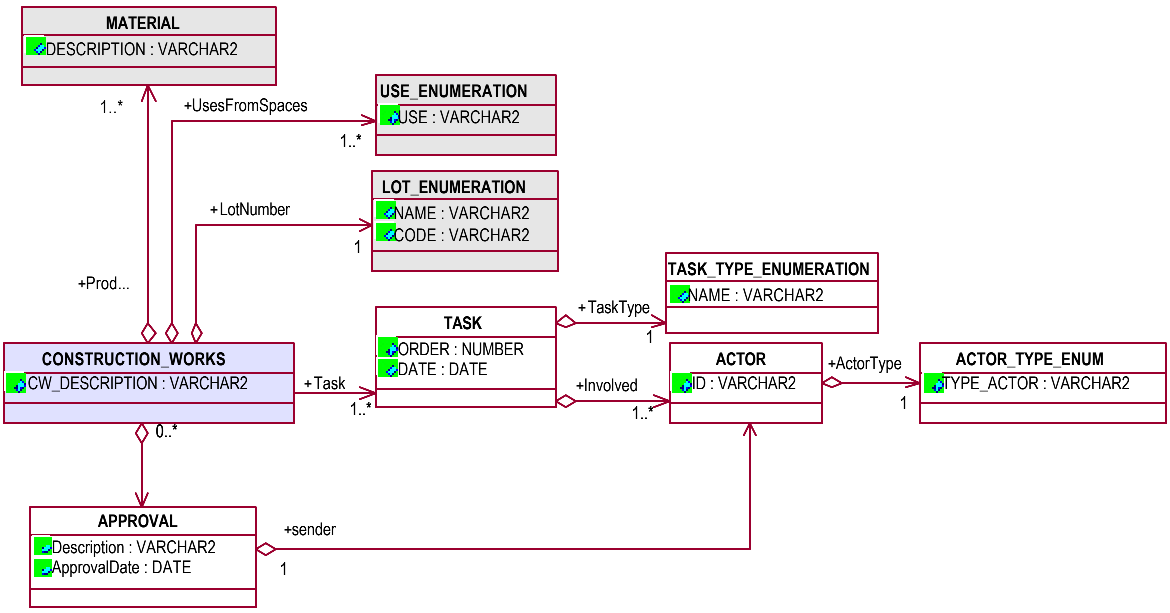

Figure 9. A technical solution structure from a corporate memory database

A query is made by setting the attributes of the classes that best describes the context. With the help of a distance formula, the system returns a set of construction works, ordered according to the nearest solution. We'll talk about knowledge management of technical solutions.

8. TECHNOLOGY AND TOOLS

To answer a cooperative context, we have based this sub-system on a web environment that allows to manage good concurrent access. Oracle 9i Application Server has been chosen for object technology support and database administration facilities.
We chose the Oriented Object Language Java [Harold, 2000] for its opportunities in :

? implementation of network for client/server applications,
? Good security management,
? Cross platform applications,
? Database access through native Java Data Base Connectivity and a thin driver.

The graphic files we are using are :

? DWF (Drawing Web Format) from AutoDesk Inc. for vector drawings, and
? VRML (Virtual Reality Modeling Language) for 3D graphic representation and alternative query interface.

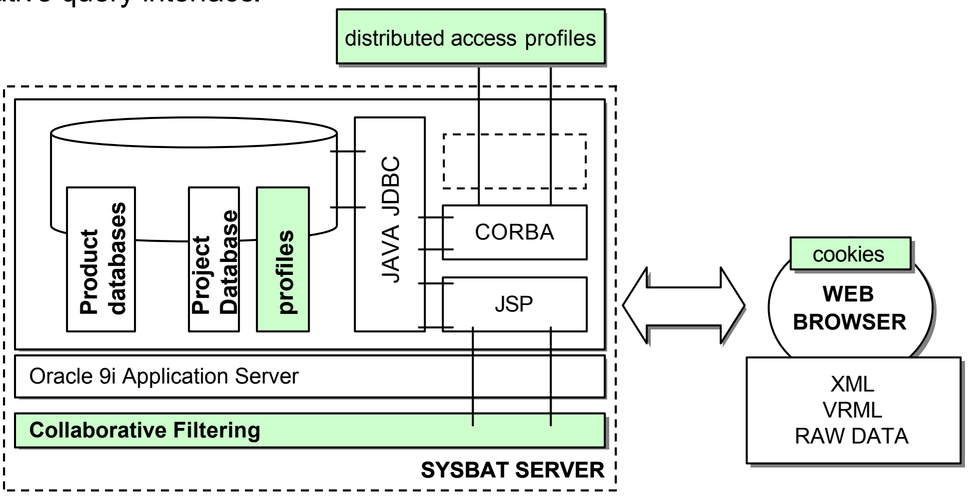

Figure. 12. System architecture and job profile management.

9. INTERNET-BASED SERVICE PROTOTYPES.

Each query sequence is stepped by 2D or 3D interactive graphics. In the building communication process, graphic drawings are the most used media because they are the only one building partners have in common. We want to increase interactivity by using them as interfaces to point out the right spaces or construction works (fig. 12.).
The following figure 13. shows the system status at the end of a query. Once the end user (e.g. the architect) has logged in, he gets his personal profile with an interactive 3D space representation. He may use it to select a specific construction work for which he gets a detailed description with all the corresponding attributes on a separate frame. We can see a list of construction works the selected space is composed of as well as attributes of a particular one (ceiling) and a 3D space representation of a structure engineer profile (in this case structure entities are the only one to be shown according to the selected profile).

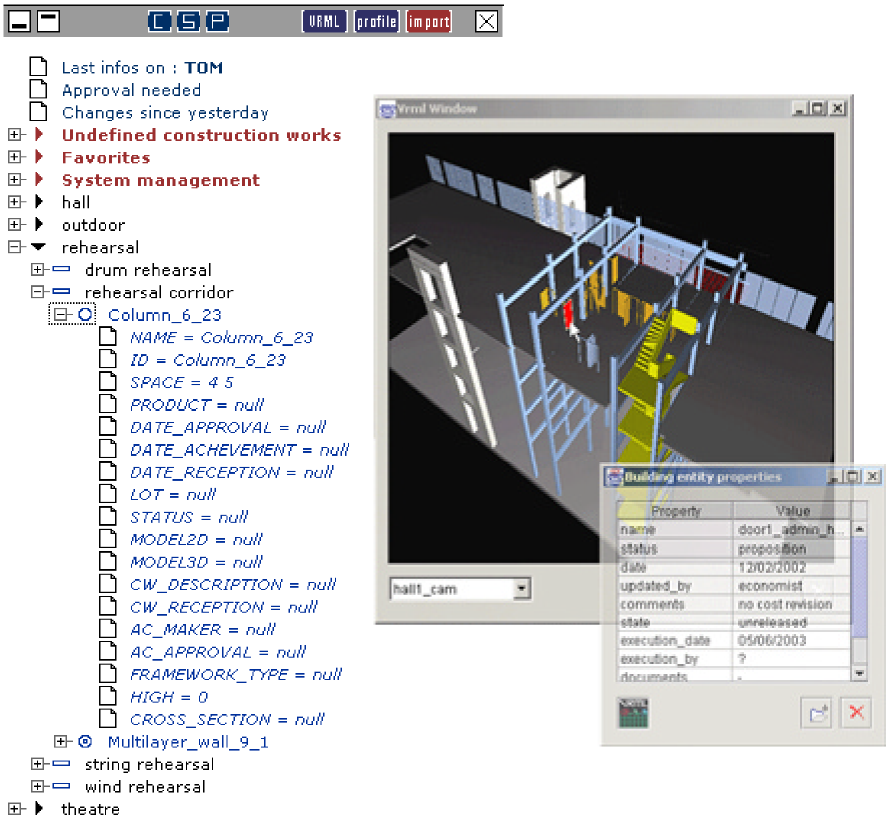

Fig. 13. System status at the end of a query.
The VRML file is generated by the server with an anchor on each group of entities, so that we can directly point to the construction work we are interested in.

10. CONCLUSION

Whereas most of the recent building information management tools are dedicated to the management of technical documents (Bentley Systems Viecon, Constructeo Projecteo, OTH derbi, etc.), our system is based on a building construction knowledge approach. It enables semantics to be added to schemas, in order to create more accurate actor electronic profiles and views.
Our work has been focused on the building product model. It aims to :

? Ensure data exchange between distant partners,
? Be able to share a common description diagram in a DBMS environment,
? Manipulate heterogeneous documents (texts, drawings, multimedia files, etc.) ,
? Ensure professional approaches on a specific industrial product,
? Help the users by developing decision support systems.

These results are important for our research center because this project has been part of a CAD software leader research since January 2000 at Nemetscheck A.G.'s (Allplan, Allfa, palladio X, etc.). This firm wants to improve the links between the building CAD systems and the DBMS using the Internet for distributed partners to share graphical and non-graphical building information data.
Our next objective is now to extend this system to the stages that follow the design and engineering steps, namely realization and operating phases, also integrating the building processes models. In addition, we are working on a data repository for electronic building documentation. This kind of data warehouse could fill a gap between spread information among the network and their accessibility.

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